UNIVERSITI PUTRA MALAYSIA

RESPONSE OF OIL PALM SEEDLINGS PLANTED ON HIGHLY WEATHERED ACID SOILS TO MAGNESIUM FERTILIZERS

AZHAM MOHAMAD

FP 2003 12

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By

AZHAM MOHAMAD

Thesis Submitted in Fulfilment of the Requirement for the Degree of Master of Agricultural Science
Universiti Putra Malaysia

May 2003

DEDICATION

In the name of Allah the most graceful and the most merciful

Especially dedicated to my beloved parents

Hj. Mohamad bin Abdullah

and

Hajjah Saodah

and to my beloved fiancé, Intan Soraya Bt Che Sulaiman

and other family members for their love and care.

Abstract of the thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Agricultural Science

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May 2003

Chairman : Syed Omar Syed Rastan, Ph.D.

Faculty : Agriculture

Magnesium (Mg) is an important nutrient for oil palm growth and Mg fertilization is recommended during immature stage to ensure no early growth limitation. Most Malaysian acid soils are low in exchangeable Mg and inadequate for optimum plant performance. This study was conducted to evaluate the effect of Mg fertilization on the growth of oil palm seedlings using two types of Mg fertilizers; kieserite and CIMA-Mg (a local synthetic industrial Mg sulphate).

Two studies were carried out, a nursery experiment with two types of acid soils and a nutrient solution experiment. In both studies, the growth of oil palms seedlings was evaluated by recording plant height, trunk girth, and plant tops and roots dry weight. Chlorophyll content in fronds number 3 and 9 were measured using chlorophyll meter SPAD-502. Nutrient tissue analysis was performed to determine the concentrations of magnesium (Mg), phosphorus (P), potassium (K) and calcium (Ca) in fronds number 3 and 9. Analysis of total and exchangeable Mg in soil was also conducted to determine the Mg status of the soil after the experiment.

In both experiments, oil palm fertilized with Mg showed a significant increased in trunk girth, plant top and root dry weight when compared to control. Magnesium deficiency symptom was observed at the age of 8 months in nutrient solution experiment, while 10 months in acid soils. The symptom was observed in frond number 9 with the reading of chlorophyll content dropped to 22.90 SPAD at the time of harvesting. The critical value for chlorophyll content in frond number 9 was 42.78 SPAD. All palms treated with Mg fertilizers had Mg concentrations in frond number 9 ranged between 0.28% - 0.34% for nursery experiment and 0.22% - 0.34% for nutrient solution experiment. The mean concentrations of Mg in frond number 9 for control palms were between 0.03% - 0.08%. An antagonistic effect was observed between Mg and both K and Ca in all experiments. However, the synergistic effect between Mg and P was only observed in the nursery experiment but not obvious in the nutrient solution experiment.

Both soils treated either with kieserite or CIMA-Mg was rated as relatively sufficient in term of exchangeable Mg status except for Prang series fertilized with kieserite that was rated as relatively high. In soils fertilized with kieserite, most of the Mg was in the exchangeable form, 178 μg Mg kg^{-1} and 412 μg Mg kg^{-1} for Bungor and Prang series soil, respectively, while for soil treated with CIMA-Mg were 126 μg Mg kg^{-1} for Bungor series and 196 μg Mg kg^{-1} for Prang series soil. The study suggested that both kieserite and CIMA-Mg were suitable as a source of Mg fertilizers in oil palm nursery to supply Mg for the growth of the seedlings. The Ca content present in the CIMA-Mg, probably help to improve root proliferation especially during the early growth of the oil palm seedlings.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi syarat keperluan untuk Ijazah Master Sains Pertanian

RESPONS ANAK KELAPA SAWIT YANG DITANAM DI TANAH ASID TERLULUHAWA TINGGI TERHADAP BAJA MAGNESIUM

Oleh

AZHAM MOHAMAD

Mei 2003

Pengerusi : Syed Omar Syed Rastan, Ph.D

Fakulti : Pertanian

Magnesium (Mg) adalah salah satu nutrien penting untuk pertumbuhan kelapa sawit dan pembajaan Mg adalah disyorkan semasa pertumbuhan vegetatif untuk memastikan pertumbuhan tidak terbantut. Kebanyakan tanah asid di Malaysia mengandungi Mg tukarganti yang rendah dan tidak mencukupi untuk prestasi tumbuhan yang optimum. Kajian ini dijalankan untuk menilai kesan pembajaan Mg ke atas tumbesaran anak kelapa sawit menggunakan dua sumber baja Mg; kieserite dan CIMA-Mg (sejenis Mg sulfat sintetik tempatan).

Dua kajian telah dijalankan iaitu eksperimen di tapak semaian menggunakan dua jenis tanah asid dan eksperimen larutan nutrien. Dalam kedua-dua kajian, pertumbuhan anak kelapa sawit dinilai melalui tinggi pokok, ukur lilit pangkal pokok, berat kering bahagian atas dan akar pokok. Kandungan klorofil dari pelepah ke 3 dan ke 9 diukur menggunakan meter klorofil SPAD-502. Analisis nutrien dalam tisu dilakukan untuk menentukan kepekatan magnesium (Mg), fosforus (P), kalium (K) dan kalsium (Ca) dalam pelepah ke 3 dan ke 9. Analisis jumlah Mg dan Mg tukarganti dilakukan untuk menilai status Mg dalam tanah selepas eksperimen.

Dalam kedua-dua eksperimen, pokok yang dibaja dengan Mg menunjukkan peningkatan ketara dari segi ukur lilit pangkal pokok, berat kering bahagian atas

pokok dan akar berbanding dengan kawalan. Simptom kekurangan Mg dapat dilihat apabila pokok berumur 8 bulan bagi eksperimen larutan nutrien dan 10 bulan bagi tanah asid. Simptom tersebut diperhatikan pada pelepah ke 9 dengan bacaan kandungan klorofil jatuh ke 22.90 SPAD ketika penuaian. Nilai kritikal bagi kandungan klorofil pada pelepah ke 9 adalah 42.78 SPAD. Kesemua pokok yang dirawat dengan baja Mg mengandungi kepekatan Mg pada pelepah ke 9 antara 0.28% - 0.34% bagi eksperimen di tapak semaian dan 0.22% - 0.34% bagi eksperimen larutan nutrien. Purata kepekatan Mg dalam pelepah ke 9 bagi pokok kawalan adalah antara 0.03% - 0.08% bagi kedua-dua eksperimen. Kesan antagonistik dilihat antara Mg dan kedua-dua K dan Ca dalam semua eksperimen. Walau bagaimanapun, kesan sinergi antara Mg dan P hanya dapat dilihat dalam eksperimen di tapak semaian.

Kedua-dua tanah yang dibaja dengan kieserite atau CIMA-Mg dikelaskan sebagai mengandungi Mg tukarganti yang sederhana kecuali tanah siri Prang yang dibaja dengan kieserite yang dikelaskan sebagai tinggi. Tanah yang dibaja dengan kieserite, kebanyakan Mg adalah dalam bentuk tukarganti iaitu 178 μg Mg kg^{-1} dan 412 μg Mg kg^{-1} masing-masing bagi siri Bungor dan siri Prang, manakala bagi tanah yang dibaja dengan CIMA-Mg pula adalah 126 μg Mg kg^{-1} untuk siri Bungor dan 196 μg Mg kg^{-1} bagi siri Prang. Kajian ini menunjukkan, kedua-dua kieserite dan CIMA-Mg adalah sesuai sebagai sumber baja Mg bagi kelapa sawit di tapak semaian untuk membekalkan Mg bagi pertumbuhan anak kelapa sawit. Kandungan Ca di dalam CIMA-Mg mungkin dapat membantu perkembangan akar terutamanya ketika awal pertumbuhan anak kelapa sawit.

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation and deepest gratitude to Dr. Syed Omar Syed Rastan the Chairman of the Supervisory Committee for his valuable advice, guidance and constructive criticism during the preparation of this thesis. The author is also grateful to Assoc. Prof. Dr. Ahmad Husni Mohd Hanif and Dr. Zin Zawawi Zakaria, the members of the Advisory Committee for their invaluable assistance and guidance and also to Assoc. Prof. Dr. Anuar Abdul Rahim for his invaluable suggestions and comments of this thesis.

It is the gratefulness and thankfulness of the author to the entire management of Cement Industries of Malaysia (CIMA), Chuping, Perlis, with special reference to En. Rosli Sharif, Mr. Liew Saik Wai and Mr. Lee Hor Seang for the dedication and commitment to the partnership in the collaborative research and also for the financial supports and funding. Special thanks are also extended to the staff of MPOB/UKM Research Station, Bangi with special reference to the Station Manager, Hj Mohd Ariffin Jurmi for their help and permission to use the nursery.

The author extends his deepest gratitude to his lovely family and fiancé, Intan Soraya Bt. Che Sulaiman for their support, understanding, patience, encouragement and good cheer when the going was rough. Special thanks are also extended to all staff in the Department of Land Management, Faculty of Agriculture, UPM for their assistance and friendship throughout the course of study.

I certify that an Examination Committee met on 26th May 2003 to conduct the final examination of Azham Mohamad on his Master of Agricultural Science thesis entitled "Response of Oil Palm Seedlings Planted on Highly Weathered Acid Soils to Magnesium Fertilizers" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Anuar Abdul Rahim, Ph.D.
Associate Professor,
Faculty of Agriculture,
Universiti Putra Malaysia
(Chairman)

Syed Omar Syed Rastan, Ph.D.
Faculty of Agriculture,
Universiti Putra Malaysia
(Member)

Ahmad Husni Mohd Hanif, Ph.D.
Associate Professor,
Faculty of Agriculture,
Universiti Putra Malaysia
(Member)

Zin Zawawi Zakaria, Ph.D.
Malaysian Palm Oil Board,
Bangi, Selangor
(Member)

GULAM RUSUL RAHMAT ALI, Ph.D.
Professor/Deputy Dean,
School of Graduate Studies,
Universiti Putra Malaysia

Date: 22 AUG 2003

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Agricultural Science. The members of the Supervisory Committee are as follows:

Syed Omar Syed Rastan, Ph.D.
Faculty of Agriculture,
Universiti Putra Malaysia
(Chairman)

Ahmad Husni Mohd Hanif, Ph.D.
Associate Professor,
Faculty of Agriculture,
Universiti Putra Malaysia
(Member)

Zin Zawawi Zakaria, Ph.D.
Malaysian Palm Oil Board,
Bangi, Selangor
(Member)

……………………………

AINI IDERIS, Ph.D,
Professor / Dean,
School of Graduate Studies
Universiti Putra Malaysia

Date: 15 SEP 2003

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been acknowledge. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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AZHAM MOHAMAD

Date: 16 July 2003

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LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometer
Ca	Calcium
CIRP	Christmas Island Rock Phosphate
FFB	Fresh Fruit Bunch
GML	Ground Magnesium Limestone
H_2SO_4	Sulphuric Acid
HCl	Hydrochloric Acid
HNO_3	Nitric Acid
K	Potassium
LSD	Least Significant Difference
Mg	Magnesium
MgO	Magnesium Oxide
MPOB	Malaysian Palm Oil Board
N	Nitrogen
NH_4OAc	Ammonium Acetate
P	Phosphorus
PORIM	Palm Oil Research Institute of Malaysia
PORLA	Palm Oil Registration and Licensing Agency
RCBD	Randomize Complete Block Design
SMS	Synthetic Magnesium Sulphate

CHAPTER 1

INTRODUCTION

The palm oil industry has grown to become a very important part of Malaysia's agriculture. Currently, oil palm plantations cover nearly a third of Malaysia's total cultivated area and contribute about 10% of the country's export earnings. The total oil palm planted area at the end of 2001 was 3,499,012 hectares, representing an increase of 3.50% or 122,348 hectares compared to that in 2000. From the total oil palm planted area, 85.89% was matured while the other 14.11% represented newly planted areas (Malaysian Palm Oil Board, 2002).

The Malaysian palm oil industry showed a remarkable performance in 2001. The production of crude palm oil increased by nearly 1.00 million tons or 8.14% to 11.80 million tons from 10.84 million tons recorded in 2000. The increase was contributed by the expansion in matured area, improved yield and higher oil extraction rate (Malaysian Palm Oil Board, 2002). In term of exports, the total exports of oil palm product, constituting of palm oil, palm kernel oil, palm kernel cake, oleochemicals and finished products increased substantially by 2.25 million tons or 18.19% to 14.62 million tons compared to 12.37 million tons in 2000 (Malaysian Palm Oil Board, 2002).

The importance of fertilizers in oil palm cultivation is well established (Foster et al., 1986). Until recently, fertilizers accounted for about 25% of the agricultural cost of fresh fruit bunch (FFB) production (Nazeeb, 1997). However, with the beginning of the global economic crisis in 1997, the Malaysian Ringgit has depreciated against the US dollar resulting in significant increases in the prices of imported fertilizers. In 1997, Malaysia has spent about RM 15.93 million for importing 56,037 tons of Mg fertilizer and the value was increased to RM 25.52 million in 1999 by importing 54,175 tons of the same fertilizer in the form of magnesium sulphate (Malaysia Agricultural Directory Index, 2002). The price of kieserite was increased from about RM 284 per ton in 1997 to RM 470 per ton in 1999. Therefore, it is important to evaluate the local Mg fertilizer against the imported Mg fertilizer in terms of their performance and cost effectiveness.

Magnesium (Mg) has been known to be essential for plant growth and development for over 100 years, but the general understanding and functions of Mg in soils and plants appear to be overlooked. Magnesium is the only metallic constituent of plant chlorophyll and also seems to play an important role in the transport of phosphate (P) in the plant (Jones, 1979). An antagonistic relationship exists among calcium (Ca) and Mg (Tinker and Ziboh, 1959) and potassium (Tinker and Smilde, 1963; Hagstrom, 1997), because these nutrients compete for uptake by plant roots. The synergistic effects also occur between Mg and P (Russell, 1973 and Jones, 1979). Magnesium is therefore important for the efficient use of other nutrients and directly influences the economy of fertilizer application. Research on Mg in oil palm seedlings is important as it can provide useful information about Mg nutrition in oil palm at immature stage which is still lacking. Furthermore, the requirement for Mg fertilizer has increased due to the increasing trend of replanting and new planting areas in Peninsular Malaysia and Sarawak.

Objectives

The objectives of this research were as follows:

1. To study the effect of two types of magnesium fertilizers on the growth of oil palm seedlings planted on highly weathered acid soils.
2. To study the relationship of phosphorus, calcium and potassium uptake under magnesium deficient palm at nursery stage.

CHAPTER II

LITERATURE REVIEW

Overview of Magnesium Status in Tropical Soil

Hardter (1997) characterized magnesium (Mg) in soil into three main fractions:

1. Matrix Mg (Mg in the crystal lattices of soil minerals)
2. Exchangeable Mg (adsorbed Mg on the soil surfaces)
3. Soluble Mg (Mg in the soil solution)

Matrix Mg constitutes about 90-99% of total Mg in the soil. Although matrix Mg is of several orders of magnitudes larger than the amount of Mg required by plants, however, it does not reflect the Mg supplying power of the soil since plants take up Mg exclusively from the soil solution. Exchangeable Mg content that determines the amount of adsorbed Mg that can be readily released into the soil solution is a better indicator of the soil's capacity to supply Mg to plants (Hardter, 1997).

Soils of the humid tropics had gone through intensive processes of weathering resulting in losses of basic elements. The situation is aggravated when the land is cleared for the establishment of crops. During clearing, as much as 80% of exchangeable Mg in the soil is lost (Hardter, 1997). Removal of vegetative covers and destruction of organic matter in the soil were found to contribute to the depletion of exchangeable Mg, as these organic materials are agents that contain and retain large amount of available plant nutrients. In Malaysia with about 23 million hectares of acid soils, exchangeable Mg is generally found to be low and inadequate for optimum plant performance (Shamshuddin et al., 1991). Magnesium deficiencies are most likely to occur.

Magnesium, after nitrogen (N) and potassium (K), is quantitatively the third important nutrient for oil palm growth. Foster et al. (1986) reported that, the application of high rates of both N and K fertilizers tend to depress the uptake of Mg and can induced a deficiency of this nutrient on sedentary soils, which generally contain only a moderate native level of this exchangeable cation. Thus application of Mg fertilizer is recommended on sedentary soils during immature stage to ensure no early growth limitation and to build up Mg level in soils.

Data in Table 2.1 shows the critical and optimum levels of nutrients in soil for oil palm. Generally, Mg in soil at the range between 24-48 mg kg^{-1} was considered to be critical for oil palm cultivation. Data in Table 2.2 shows the exchangeable Mg in some Malaysian soils. Most of the inland soil such as Melaka, Rengam, Serdang, Ulu Tiram and Chemor series were considered to have a very low content of exchangeable Mg.

Table 2.1: Critical and optimum levels of nutrients in soil for oil palm.

Nutrient	Critical level (Low)	Optimum level (Moderate)
N	500-1500 mg kg $^{-1}$	1500-3000 mg kg $^{-1}$
P	40-80 mg kg $^{-1}$	80-120 mg kg $^{-1}$
K	39-78 mg kg $^{-1}$	78-195 mg kg $^{-1}$
Mg	24-48 mg kg $^{-1}$	48 –120 mg kg $^{-1}$

Source: Hew and Ng, 1968.

Table 2.2: Exchangeable magnesium in some Malaysian soils.

Soil Series	Exch. Mg (cmol $_c$ kg^{-1})	mg kg $^{-1}$
Selangor	1.80	216.0
Kuantan	0.40	48.0
Segamat	0.35	42.0
Batu Anam	0.33	39.6
Melaka	0.13	15.6
Rengam	0.09	10.8
Serdang	0.08	9.6
Ulu Tiram	0.07	8.4
Chemor	0.06	7.2

Source: Pushparajah and Amin, 1977.